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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	6926 US
First Inventor or Application Identifier	NIKHIL DESHPANDE
Title	SIGNAL TYPE IDENTIFICATION
Express Mail Label No.	EL638020037US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231**

1. [X] * Fee Transmittal Form *(e.g., PTO/SB/17)* *(Submit an original and a duplicate for fee processing)*
2. [X] Specification [*Total Pages* 10] *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 3]
4. Oath or Declaration [*Total Pages* 2]
   - a. [X] Newly executed (original or copy)
   - b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 16 completed)*
     - i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

** NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).*

5. [ ] Microfiche Computer Program *(Appendix)*
6. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   - a. [ ] Computer Readable Copy
   - b. [ ] Paper Copy (identical to computer copy)
   - c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
13. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
15. [ ] Other: .....

16. **If a CONTINUING APPLICATION,** *check appropriate box, and supply the requisite information below and in a preliminary amendment:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: _____ / _____

Prior application information: Examiner _____ *Group / Art Unit:* _____

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

[ ] *Customer Number or Bar Code Label* *(Insert Customer No. or Attach bar code label here)* or [X] *Correspondence address below*

Name	Francis I. Gray				
	TEKTRONIX, INC.				
Address	MS 50-LAW				
	P.O. Box 500				
City	Beaverton	*State*	Oregon	*Zip Code*	97077
Country	U.S.A.	*Telephone*	(503) 627-7261	*Fax*	(503) 627-7119

Name (Print/Type)	Francis I. Gray	*Registration No. (Attorney/Agent)*	27,788
Signature	Francis I. Gray	*Date*	June 2, 2000

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TITLE OF THE INVENTION

SIGNAL TYPE IDENTIFICATION

BACKGROUND OF THE INVENTION

The present invention relates to radio frequency (RF) signal measurements, and more particularly to the signal type identification of an unknown signal.

In measuring and testing RF systems there occur from time to time interfering signals. This may show up on a spectral display, such as that generated by a spectrum analyzer, as an extraneous signal in the frequency domain, as shown in Fig. 1. A skilled operator, technician or engineer may manually identify the interfering signal by making appropriate adjustments to the spectrum analyzer control parameters and having skill in identifying those parameters that are unique to different types of signals, both modulated and unmodulated. There are many signal types that may occur in the normal environment, such as IS-95 CDMA signals, North American Digital Cellular (NADC) TDMA signals, Global System for Mobile (GSM) TDMA signals, Analog Mobile Phone System (AMPS) FM signals, Continuous Wave (CW) signals and W-CDMA or CDMA 2000 signals.

In normal field testing and measuring conditions the operator may not be a skilled operator, technician or engineer and, thus, may not have the skill and experience necessary to discriminate and identify to which of the signal categories a particular unknown signal belongs. What is desired

is an instrument that automatically identifies an unknown modulated signal with a reasonable confidence level for the unskilled operator.

BRIEF SUMMARY OF THE INVENTION

Accordingly the present invention provides a method of modulation identification for an unknown modulated signal. A frequency spectrum is displayed in a conventional manner and an operator selects an unknown signal so displayed in a conventional manner, such as touching the screen, adjusting a cursor, clicking a mouse cursor and the like. The selection activates an identification algorithm which processes the data representing the signal according to specified parameters. Typical parameters may be frequency, occupied bandwidth (OBW) and complementary cumulative distribution function (CCDF) of the peak power of the signal. Occupied bandwidth may be used to particularly identify the signal modulation for most signal modulation candidates. Finally CCDF may be used where more than one signal modulation candidate has the same OBW. A table or database of spectral assignments for known modulated signals may be used to select signal modulation candidates based on frequency. The resulting identification may be displayed and may include frequency, expected characteristics, whether the signal is modulated or not, detected modulation and other pertinent information.

The objects, advantages and other novel features of the present invention are apparent from the following detailed description when read in conjunction with the appended claims and attached drawing.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Fig. 1 is a plan view of a display of a frequency spectrum showing a known and unknown signal simultaneously.

Fig. 2 is a graphic view of a complementary cumulative distribution function for an NADC digital signal.

Fig. 3 is a graphic view of a complementary cumulative distribution function for an AMPS analog signal.

Fig. 4 is a block diagram view for an architecture of an instrument that includes signal type identification according to the present invention.

Fig. 5 is a flow chart view of an algorithm for signal type identification according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

From the list of signals that need to be identified, it is seen that almost every signal type has some specific "signature" parameter. One such parameter may be the frequency. A database or table of stored information containing spectral band assignments for various types of modulated signals may be used. When a signal is selected by suitable means, such as cursor positioning via mouse or dial, touching or the like, the database may be consulted to see what signal or signals may be expected to exist at the selected frequency of the selected signal.

Another parameter is the "Occupied BandWidth of the signal" (OBW). Since the OBW measurement may be done directly on an

intermediate frequency (IF) signal without demodulating the signal, it is fairly straight forward using existing algorithms, such as using fast Fourier transform (FFT) and estimating the number of bins for 95% of total power. Table 1 below shows signals that may be measured, the signals that have high correlation in spectral characteristics, and the defining identification parameter.

Table 1:

SIGNAL	SIMILAR SIGNAL	HOW TO IDENTIFY
CW	30 kHz AMPS or NADC	Use OBW
30 kHz AMPS	30 kHz NADC	Use CCDF
30 kHz NADC	30 kHz AMPS	Use CCDF
200 kHz FM	200 kHz GSM	Use CCDF
200 kHz GSM	200 kHz FM	Use CCDF
CDMA IS-95	3G CDMA	UseOBW
3G CDMA	CDMA IS-95	Use OBW

Most of the signals may be discriminated among simply by calculating the OBW of the signal. The algorithm considers signals with the OBW less than 30 kHz to be CW. Problems arise in discriminating the AMPS signal from the NADC signal and the 200 kHz FM signal from the GSM signal because these signal pairs each have the same OBW. What is needed for these situations is another parameter or deciding factor that is unique to each of these signals.

Although both AMPS and NADC signals have the same OBW and look quite alike in the spectral domain, they have a fundamental difference — the AMPS signal is an analog signal while the NADC signal is a digital signal. The AMPS signal is a frequency varying, relatively constant amplitude carrier while the NADC is a carrier modulated with QPSK data. Because of this difference the AMPS signal may be classified as a "deterministic" signal while the NADC signal may be classified as a "probabilistic" signal. The determination as to whether the signal is deterministic or probabilistic may be performed relatively easily without demodulating the signal. This parameter is the Complementary Cumulative Distribution Function (CCDF) of the peak power of the signal, and may be used to distinguish between the AMPS signal and the NADC signal even if they occupy the same bandwidth. Because of the inherent digital nature of the NADC signal, it has a much "flatter" CCDF than the AMPS signal, as shown by comparing Figs. 2 and 3. The same is true for discriminating the 200 kHz FM signal from the GSM signal.

From the curves of Figs. 2 and 3 the CCDF of the AMPS signal follows typical deterministic sinusoidal characteristics where there are no observable statistical peaks below 1% probability. This makes sense since the AMPS signal is a relatively constant amplitude frequency varying sinusoid. On the other hand the NADC signal has some statistical peaks below the 1% probability point. Table 2 shows a comparison between the two CCDFs.

Table 2:

Comparison Point	CCDF for AMPS Signal	CCDF for NADC Signal
10% probability	3 dB	1.9 dB
1% probability	3.1 dB	2.6 dB
0.1% probability	NA	3.0 dB
0.01% probability	NA	3.15 dB
0.001% probability	NA	3.3 dB

Therefore these signals may be distinguished based on the CCDF characteristics of the peak power, as indicated in Table 1.

Fig. 4 shows an architecture for an instrument that includes signal type identification. When the signal is selected by an operator from the spectral display, the signal is downconverted, resampled and acquired in an acquisition memory **10** The preprocessed signal in the acquisition memory **10** is processed by a fast Fourier transform (FFT) **14**. The FFT output is then sent to a signal type identification algorithm **16** for interference measurements. The FFT may be done in either hardware or software.

The algorithm is shown in Fig. 5. There are two components to the algorithm: first the algorithm computes the occupied bandwidth **20** of the input signal; and second the algorithm further estimates the CCDF **22** of the signal and determines if the signal is analog or digital. If the OBW is equal to 30 kHz or 200 kHz, the second step **22** is bypassed. The CCDF estimation is done only if the OBW is equal to 30 kHz or 200 kHz as

determined by a decision step **24**, the bandwidths that are common to the AMPS signal and NADC signal or the FM signal and the GSM signal pairs respectively. From the OBW and CCDF results a decision **26** is made to identify the signal. As indicated above, the frequency of the signal may be compared with the database of spectral assignments to provide additional data about the possible signals. The results from the algorithm may be displayed, either on the same display as the spectral display or another interface display. The results may include frequency, expected signal characteristics, detected modulation type, if any, and other pertinent information.

Thus the present invention provides a means for identifying an unknown signal, without having to demodulate it if it is modulated, using one or more of a plurality of parameters, such as spectral band assignment, occupied bandwidth and/or complementary cumulative distribution function of peak power.

CLAIM OR CLAIMS

WHAT IS CLAIMED IS:

1. A method of identifying a signal type comprising the steps of:

selecting a signal of interest from a displayed spectral waveform for a specified range of frequencies;

processing data representing the signal of interest to ascertain characteristics of the signal of interest; and

from the characteristics of the signal of interest determining an identification of the signal type.

2. The method as recited in claim 1 wherein the determining step comprises the step of comparing the frequency of the signal of interest with a database of spectral assignments for a plurality of known signals to identify the signal type.

3. The method as recited in claim 1 wherein the processing step comprises the step of estimating from the data an occupied bandwidth for the signal of interest as one of the characteristics for input to the determining step.

4. The method as recited in claim 3 wherein the processing step further comprises the step of estimating from the data a complementary

cumulative distribution function of the peak power for the signal of interest as one of the characteristics for input to the determining step.

5. The method as recited in claim 4 wherein the determining step comprises the steps of:

inhibiting the estimating step for the complementary cumulative distribution function if the occupied bandwidth is unique to a known signal type; and

determining the identification for the signal type based upon the complementary cumulative distribution function if the occupied bandwidth is common to more than one known signal type.

6. A method of discriminating between modulation signals having the same occupied bandwidth comprising the steps of:

selecting a signal of interest from a displayed spectral waveform for a specified frequency range;

estimating an occupied bandwidth for the signal of interest from data representing the signal of interest;

estimating a complementary cumulative distribution function of peak power from the data for the signal of interest where the occupied bandwidth is common to more than one known signal type;

reporting a identification of the signal type as a function of the complementary cumulative distribution function.

ABSTRACT OF THE DISCLOSURE

A method of identifying a signal type uses parameters of the signal as a basis for automatic identification. A signal of interest is selected from a display of a spectral waveform for a specified frequency An occupied bandwidth for the signal of interest is estimated and, if the occupied bandwidth is common to more than one known signal type, a complementary cumulative distribution function of peak power for the signal of interest is estimated. The signal type may be identified as a function of these parameters.. Additionally the frequency of the signal of interest may be compared with a database of spectral assignments for known signal types to provide further information about the signal of interest.

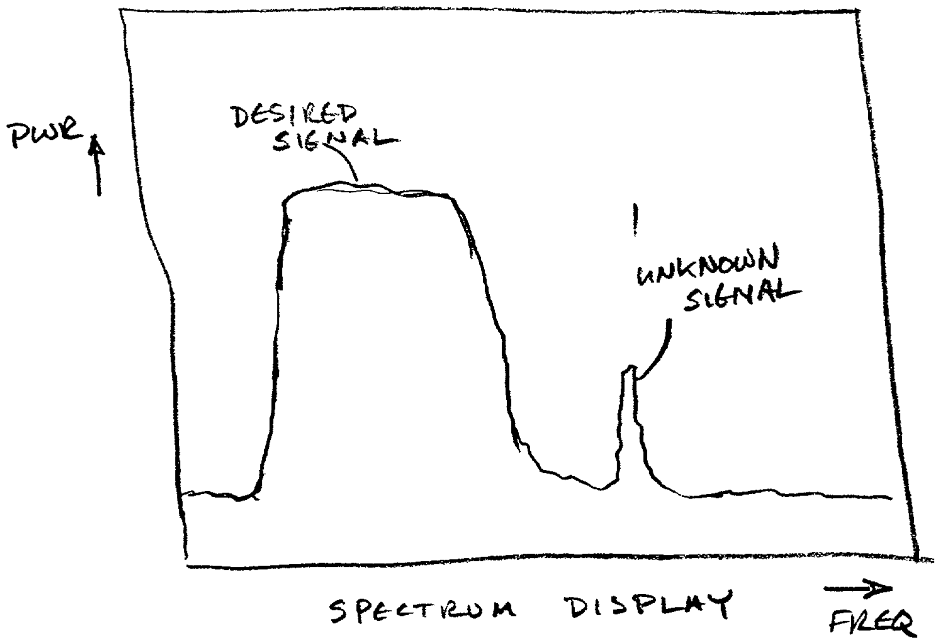
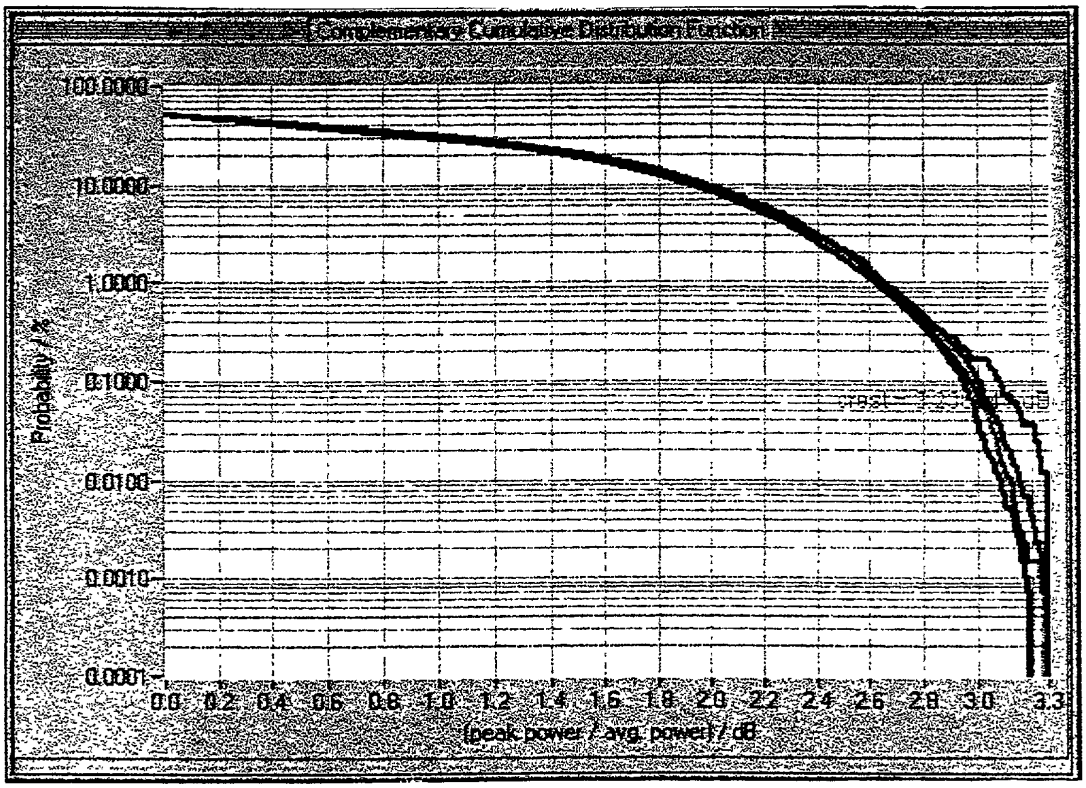


FIG. 1

FIG. 2 NADC CDF



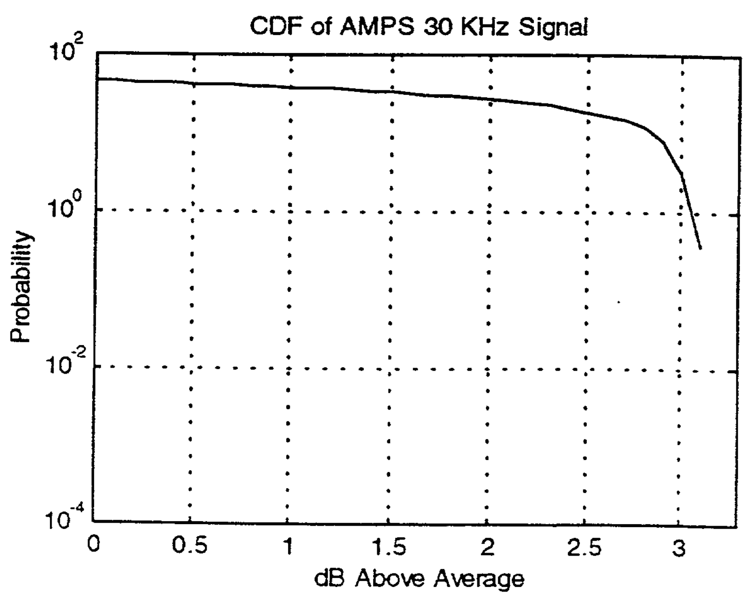


FIG. 3

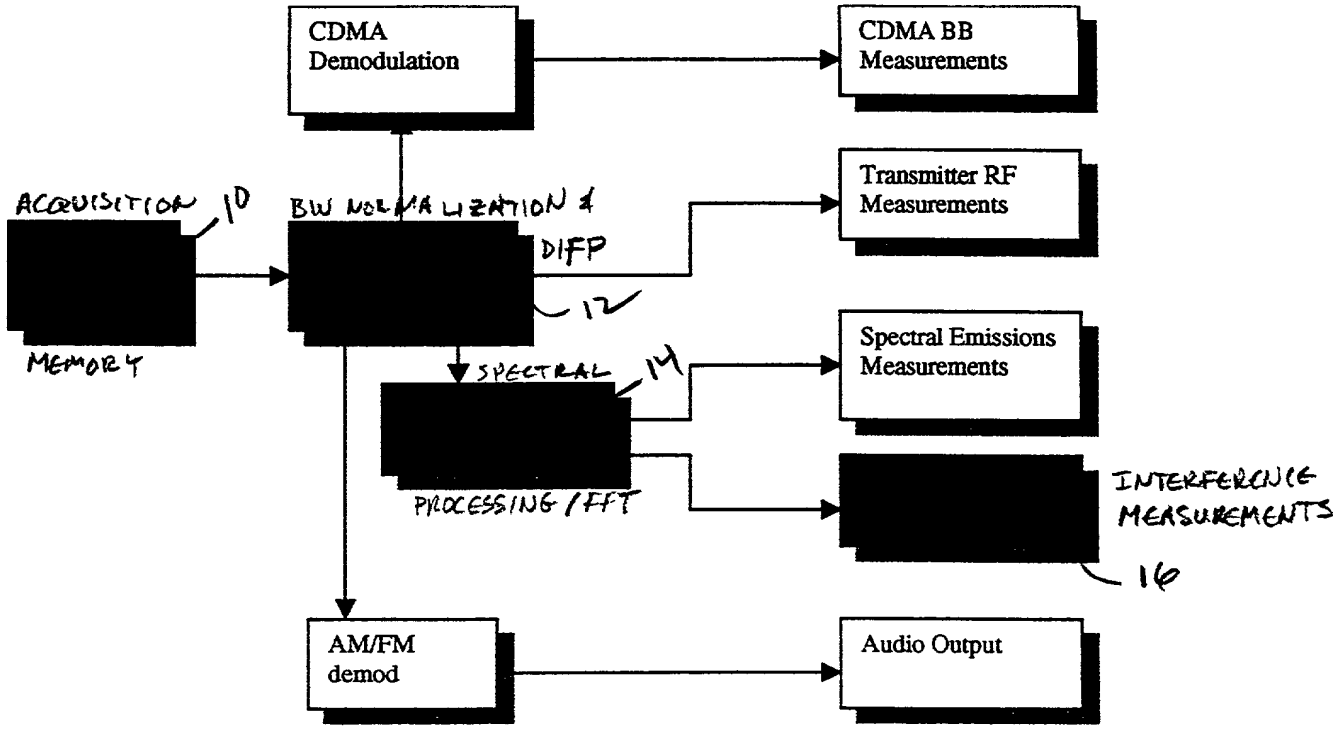

CDMA Demodulation
CDMA BB Measurements
ACQUISITION
10
BW NORMALIZATION & DIFP
Transmitter RF Measurements
12
MEMORY
SPECTRAL
14
Spectral Emissions Measurements
PROCESSING / FFT
INTERFERENCE MEASUREMENTS
16
AM/FM demod
Audio Output

FIG. 4

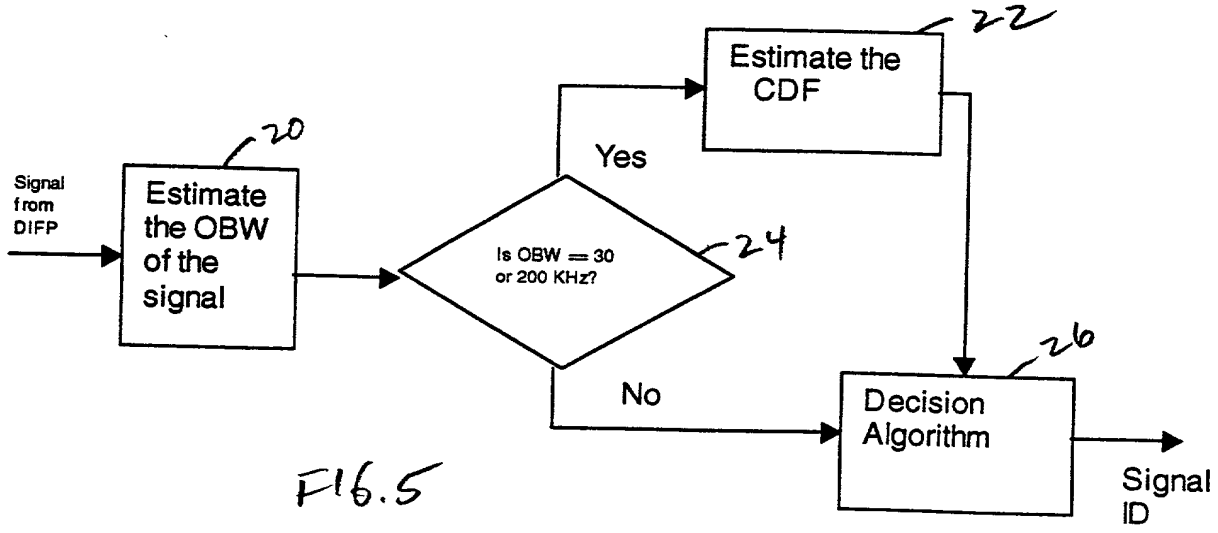

Signal from DIFP
Estimate the OBW of the signal
20
Is OBW = 30 or 200 KHz?
24
Yes
Estimate the CDF
22
No
Decision Algorithm
26
Signal ID

FIG. 5

Docket No.: 6926 US

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
SIGNAL TYPE IDENTIFICATION
the specification of which:

(check one) X is attached hereto.
__ was filed on _____, 19____ as Application Serial No. _____
and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

I have identified below any foreign application(s) for patent or inventor's certificate from which I claim foreign priority benefits under Title 35, United States Code, Section 119 and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of the above-identified specification is not disclosed in the prior United States application(s) in the matter required by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)

Docket No.: 6926 US

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

William K. Bucher, Reg. No. 32,686; Francis I. Gray, Reg. No. 27,788; Thomas F. Lenihan, Reg. No. 32,152; John D. Winkelman, Reg. No. 26,523; John Smith-Hill, Reg. No. 27,730 at telephone no. (503) 627-7261, P.O. Box 500, Delivery Station 50-LAW, Beaverton, Oregon 97077.

Address all telephone calls to Francis I. Gray at Telephone no. (503) 627-7261.

Address all correspondence to Francis I. Gray, Tektronix, Inc., P.O. Box 500, Delivery Station 50-LAW, Beaverton, Oregon 97077.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of **sole or first** inventor NIKHIL DESHPANDE

Inventor's signature _____ Date 6/1/2000

Residence Hillsboro, Oregon Citizenship India

Address 2767 N.W. Overlook Drive, Apt. 2328

Hillsboro, Oregon 97124

Full name of **second** inventor THOMAS C. HILL

Inventor's signature _____ Date 6/1/2000

Residence Beaverton, Oregon Citizenship U.S.A.

Address 19335 N.W. Walker Road

Beaverton, Oregon 97006

Docket No.: 6926 US

Full name of **third** inventor R. EBEN JENKINS

Inventor's signature R. Eb. Jen Date 01 June 2000

Residence Portland, Oregon Citizenship U.S.A.

Address 041 S.W. Mitchell

Portland, Oregon 97201

Full name of **fourth** inventor KATHRYN A. ENGHOLM

Inventor's signature Kathryn A. Engholm Date 6-1-2000

Residence Beaverton, Oregon Citizenship U.S.A.

Address 14110 S.W. Tennessee Lane

Beaverton, Oregon 97008-7447